ML-HomeWork-2

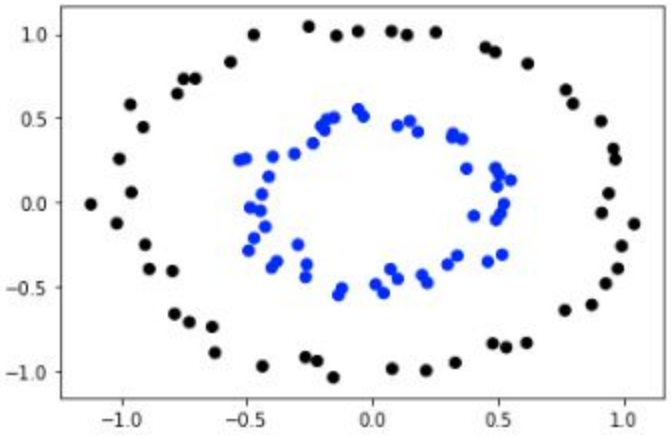
Bharath Kumar Thulasidoss

2017035

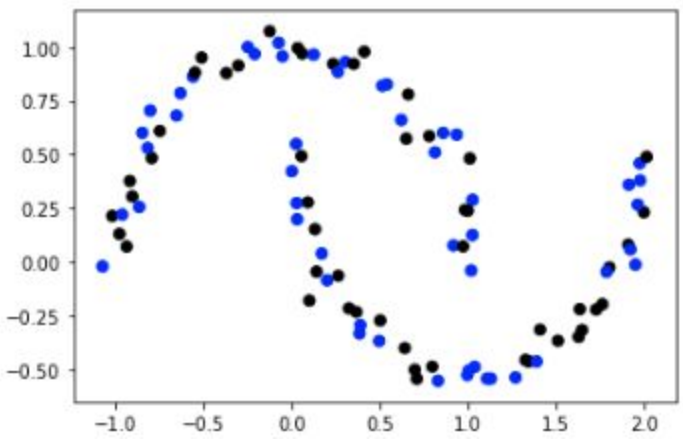
q1)

1) The plots are:

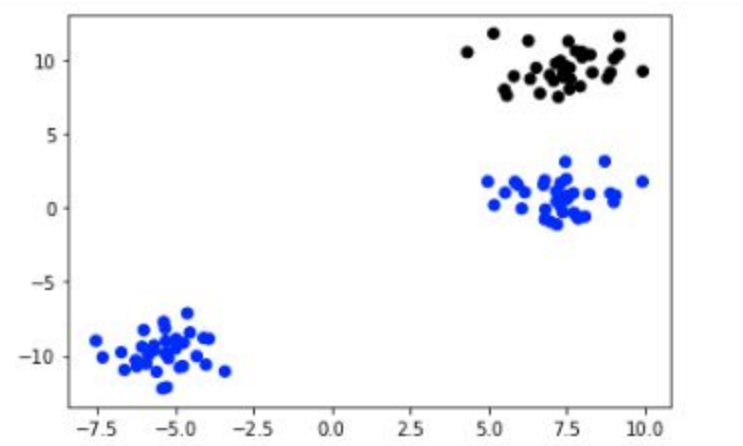
a)



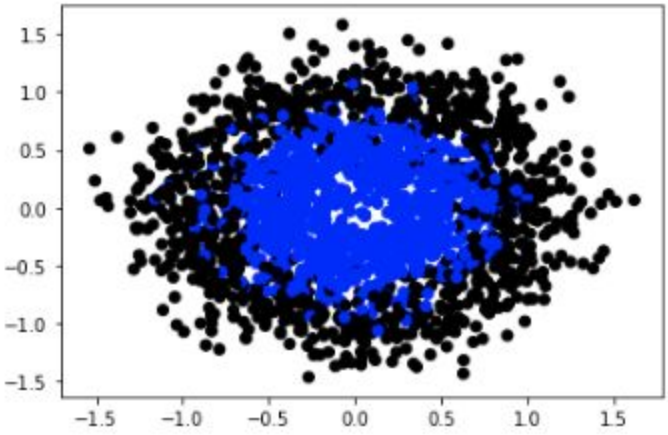
b)



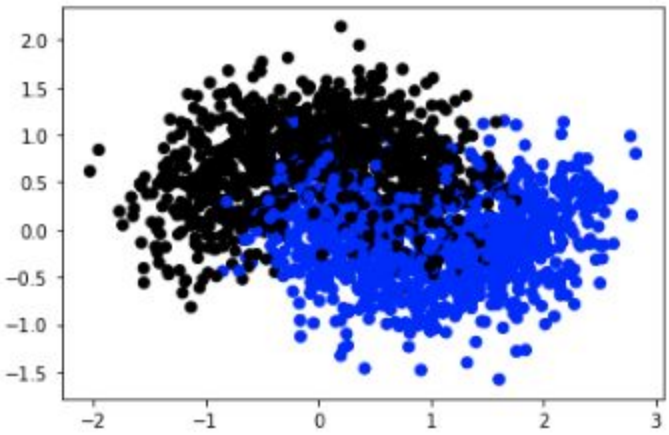
c)



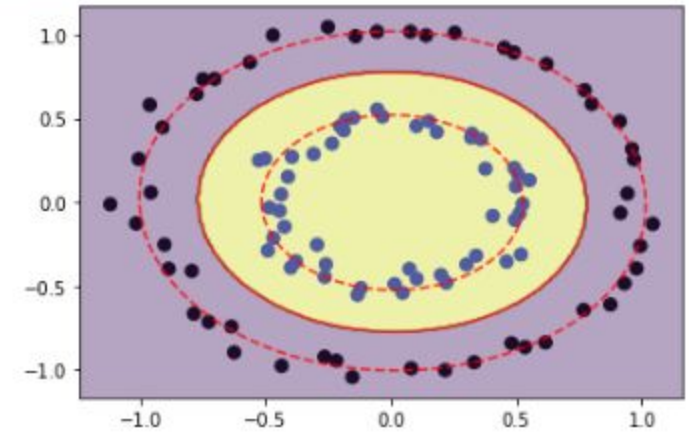
d)



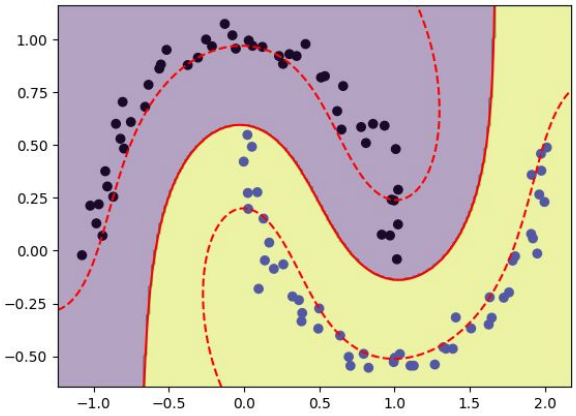
e)



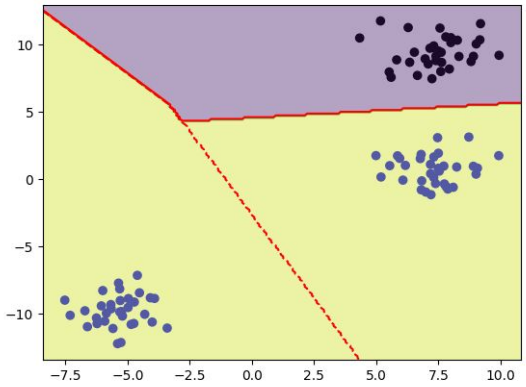
2) The kernels for different datasets are:
    a) Dataset 1: Kernel = K(x,y) = (x*(x.T))^2 where .T = transpose



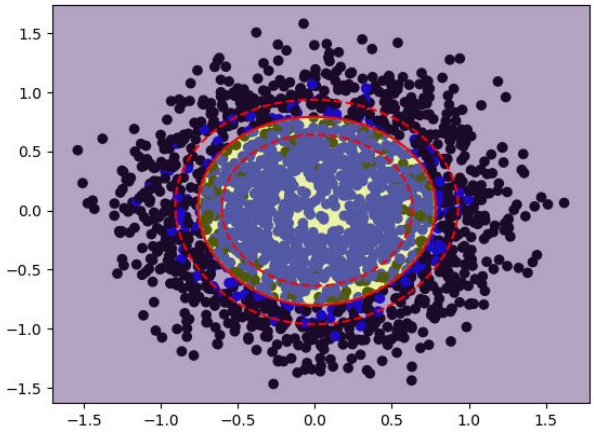
b) Dataset 2: Kernel = K(x,y) = $e^{-\|x-\mu\|^2}$



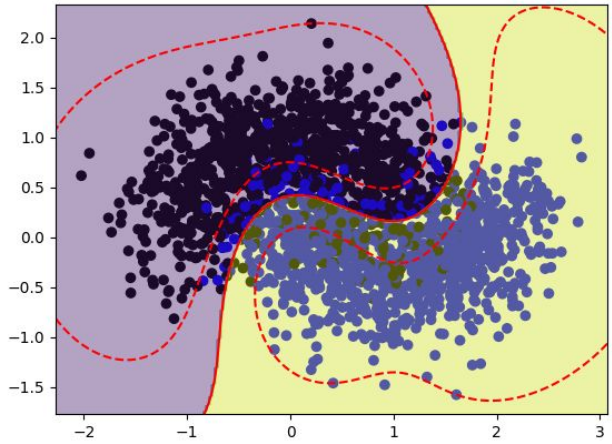
c) Dataset 3: Kernel = K(x,y) = x*([2,0],[0,1])*y.T



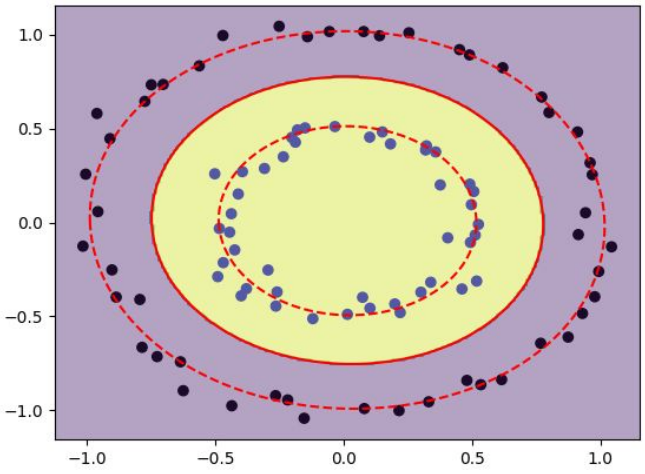
d) Dataset 4: Kernel = K(x,y) = $e^{-\|x-\mu\|^2}$ or inbuilt rbf kernel



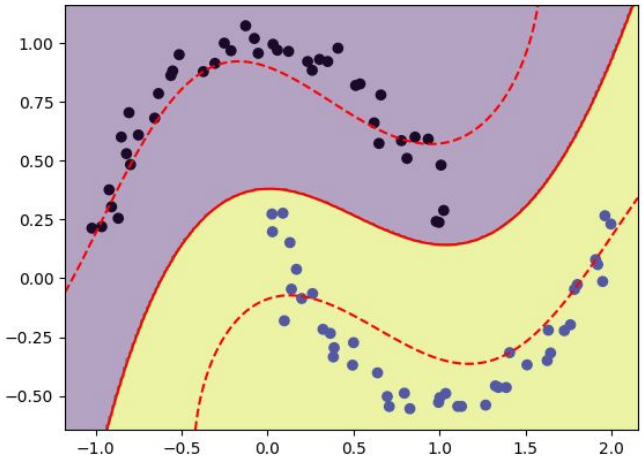
e) Dataset 5: Kernel = K(x,y) = $e^{-\|x-\mu\|^2}$ or inbuilt rbf kernel



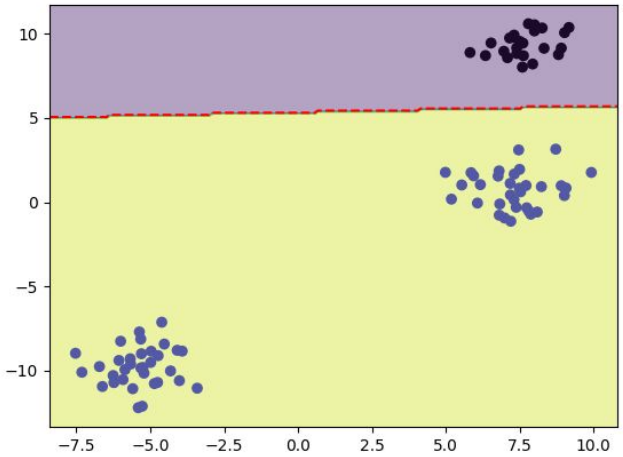
3) Outlier removals:
   a) For dataset 1: 4 outliers were removed



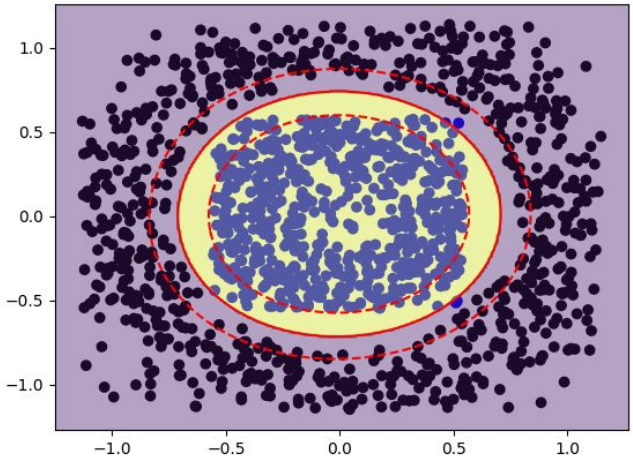
b) For dataset 2: 14 outliers were removed



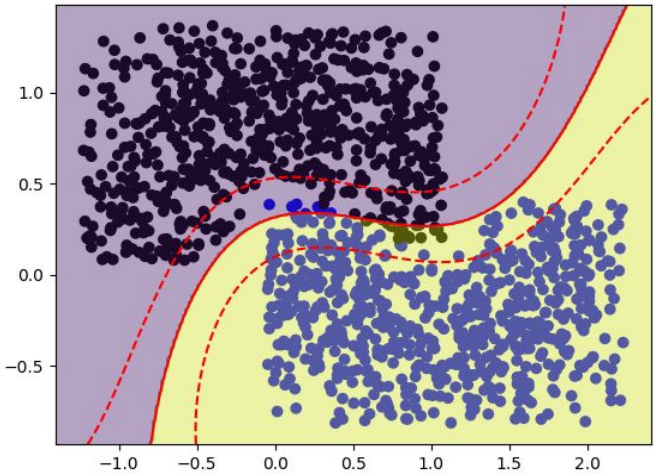
c) For dataset 3: 10 outliers were removed



d) For dataset 4: 592 outliers were removed



e) For dataset 5: 649 outliers were removed



4) For dataset 4:
   a) Linear svm :
      Train set
         Accuracy from sklearn: 0.506875
         Self accuracy : 0.506875
      Test set
         Accuracy from sklearn: 0.4725
         Self accuracy : 0.4725
   b) Rbf svm
      Train set
         Accuracy from sklearn: 0.883125
         Self accuracy : 0.88625
      Test set
         Accuracy from sklearn: 0.89
         Self accuracy : 0.8925

For dataset 5:

c) Linear svm :

Train set

Accuracy from sklearn: 0.850625

Self accuracy : 0.850625

Test set

Accuracy from sklearn: 0.8275

Self accuracy : 0.8275

d) Rbf svm

Train set

Accuracy from sklearn: 0.891875

Self accuracy : 0.885625

Test set

Accuracy from sklearn: 0.835

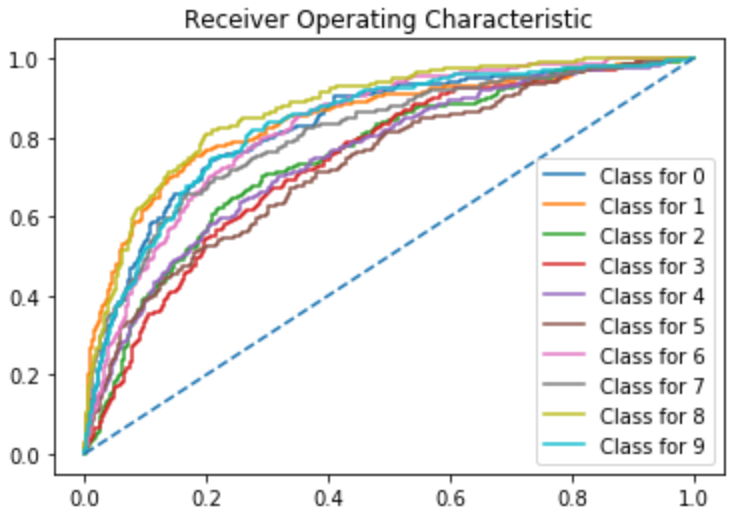
Self accuracy : 0.8475

q2) I have selected batch 1

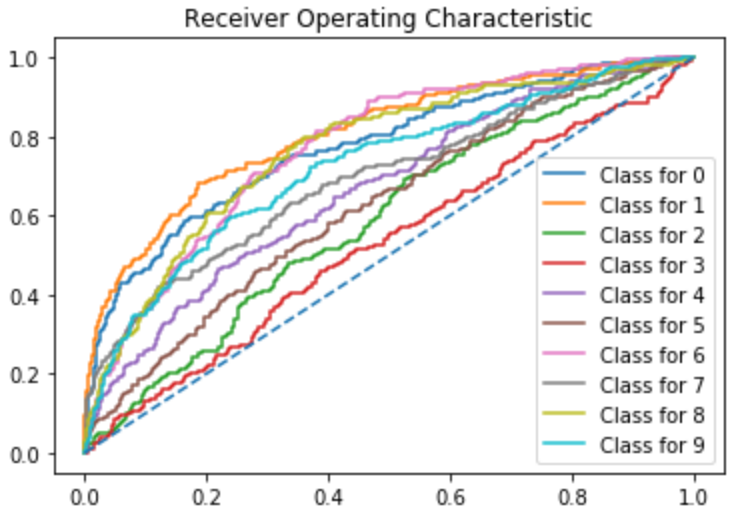
1) OnevsOne classifier for batch 1 fold 1 linear model

Model accuracy is: 0.369

Confusion Matrix: [[84 11 19 5 6 6 4 11 39 17]
[6 99 6 4 2 5 12 10 14 33]
[16 9 52 17 28 17 28 25 10 1]
[10 20 19 45 8 30 32 10 9 12]
[5 8 35 18 57 14 34 29 8 6]
[4 6 23 32 16 51 15 19 11 6]
[1 5 20 41 19 19 84 9 2 7]
[16 12 15 12 28 11 6 81 2 16]
[44 10 5 8 4 4 4 2 100 22]
[13 42 4 7 1 5 10 14 22 85]]

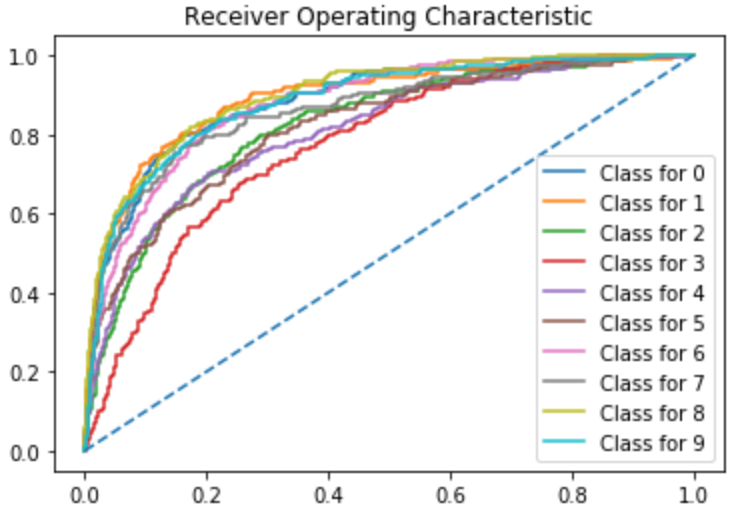


2) OnevsRest classifier for batch 1 fold 1 linear model
Model accuracy is: 0.2905
Confusion Matrix: [[80 12 17 16 4 9 6 21 20 17]
[8 93 7 9 5 7 13 10 13 26]
[23 15 36 19 26 30 19 22 11 2]
[9 23 18 26 10 30 38 8 14 19]
[8 15 19 14 47 28 36 29 10 8]
[9 22 18 17 18 38 23 13 12 13]
[4 10 11 23 31 23 80 4 11 10]
[6 14 18 15 31 11 10 57 5 32]
[53 14 13 10 2 5 8 21 56 21]
[10 47 12 7 8 5 11 22 13 68]]

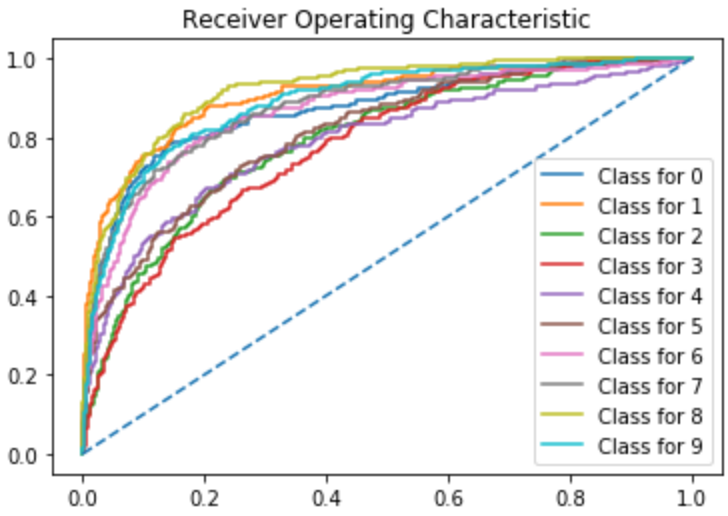


3) OnevsOne classifier for batch 1 fold 1 rbf model
Model accuracy is: 0.479
Confusion Matrix: [[103 10 14 14 3 1 3 4 38 12]

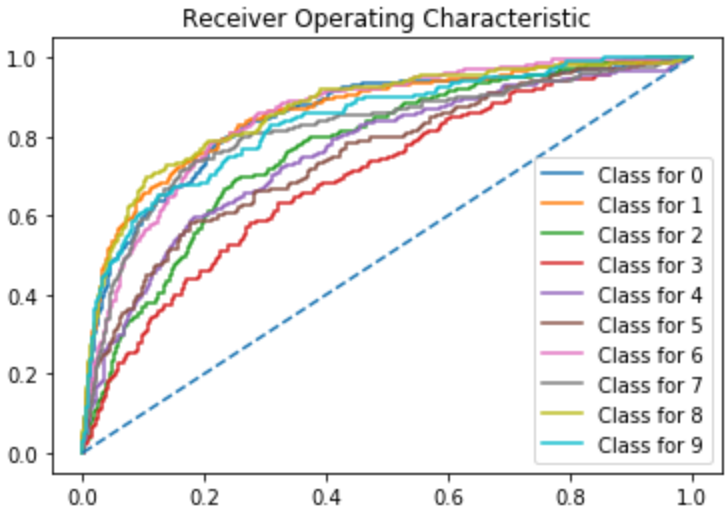
[4 106 3 5 5 3 3 6 21 35]
[17 8 80 17 28 11 23 16 2 1]
[2 11 19 61 7 33 33 7 9 13]
[9 9 31 18 78 8 26 20 10 5]
[4 6 17 37 3 68 22 18 6 2]
[4 2 20 31 20 6 110 6 1 7]
[9 5 7 19 21 8 6 106 4 14]
[22 14 4 12 3 3 3 6 124 12]
[9 18 1 12 3 7 7 11 13 122]]



4) OnevsRest classifier for batch 1 fold 1 rbf model
Model accuracy is: 0.494
Confusion Matrix: [[112 11 12 4 2 1 3 6 41 10]
[5 122 3 2 5 1 4 6 20 23]
[19 13 72 14 17 11 31 20 4 2]
[9 16 18 45 5 35 33 10 11 13]
[6 7 32 11 80 8 30 24 10 6]
[3 13 12 20 7 70 25 22 6 5]
[5 6 15 15 11 8 128 9 4 6]
[8 9 5 9 20 9 8 111 4 16]
[22 16 3 5 2 2 5 4 134 10]
[8 26 1 8 1 6 5 13 21 114]]

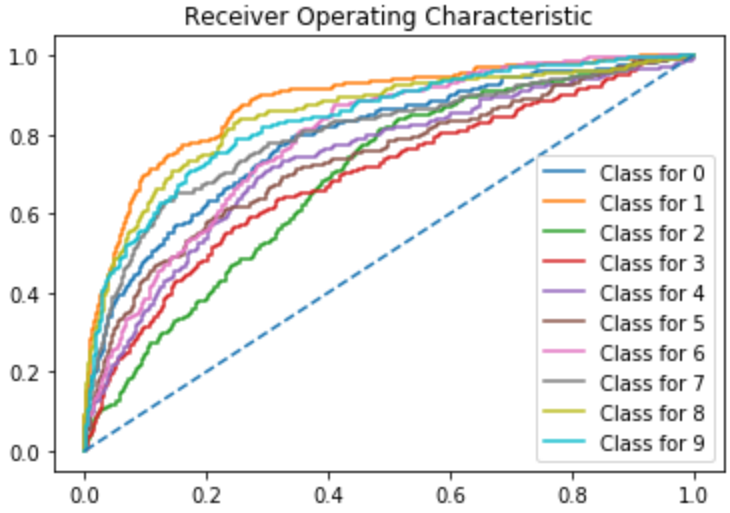


5) OnevsOne classifier for batch 1 fold 1 poly model
Model accuracy is: 0.417
Confusion Matrix: [[95 5 33 3 11 0 5 9 33 8]
[7 92 13 4 8 1 13 6 23 24]
[17 4 78 12 30 9 29 16 5 3]
[7 6 33 36 16 18 41 12 15 11]
[7 5 58 8 70 6 28 20 9 3]
[4 8 28 21 21 47 26 19 6 3]
[2 3 34 12 16 8 116 9 3 4]
[10 4 20 5 34 10 15 89 4 8]
[25 11 18 7 8 4 5 3 114 8]
[12 23 9 6 9 4 17 12 14 97]]

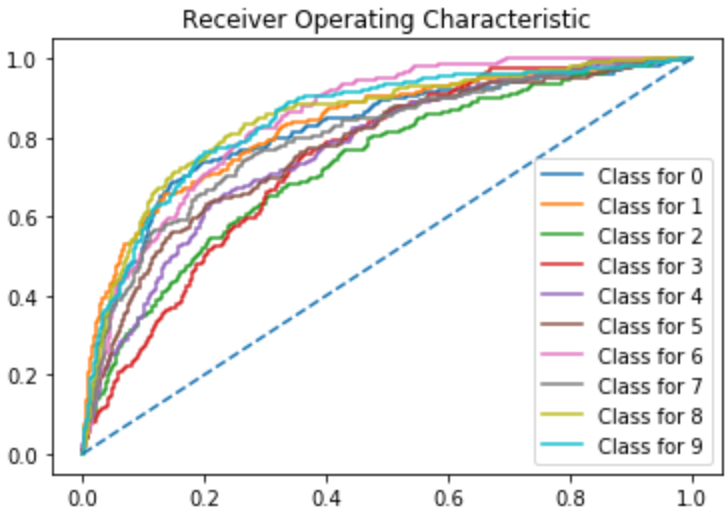


6) OnevsRest classifier for batch 1 fold 1 poly model
Model accuracy is: 0.4285

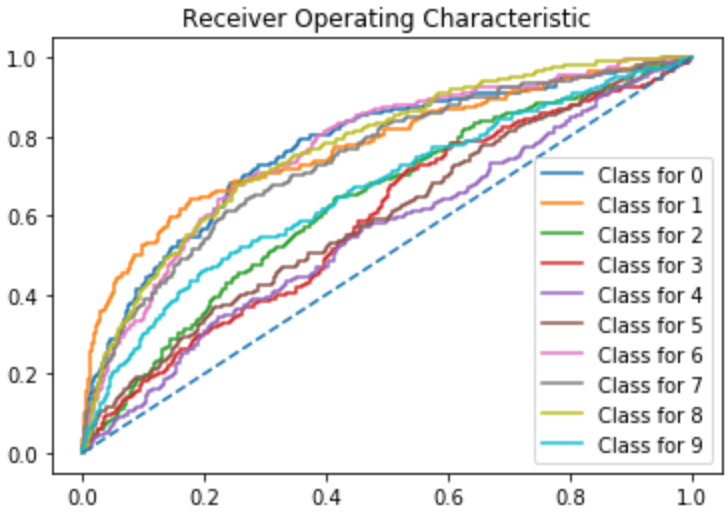
Confusion Matrix: [[86 11 19 7 10 4 7 10 41 7]
[6 113 4 8 9 0 7 6 18 20]
[20 7 48 21 28 14 29 22 5 9]
[5 15 19 47 16 24 31 9 18 11]
[11 7 33 12 78 12 24 23 11 3]
[8 7 21 26 15 55 18 22 7 4]
[5 8 21 16 18 10 103 10 6 10]
[9 7 14 11 24 10 14 99 5 6]
[24 11 5 8 6 4 2 4 129 10]
[16 26 11 13 3 7 6 8 14 99]]



7) OnevsOne classifier for batch 1 fold 2 linear model
Model accuracy is: 0.3775
Confusion Matrix: [[82 10 16 10 4 8 6 10 40 8]
[5 78 6 14 3 8 8 9 12 32]
[16 6 67 19 25 14 33 17 13 7]
[5 10 25 48 21 25 30 7 7 11]
[8 5 33 12 55 10 32 34 8 11]
[7 13 20 46 15 61 22 12 8 6]
[1 5 13 34 22 11 101 9 6 5]
[8 7 14 14 22 12 15 77 6 11]
[35 12 8 8 4 11 5 4 94 23]
[19 38 4 8 4 1 10 8 26 92]]

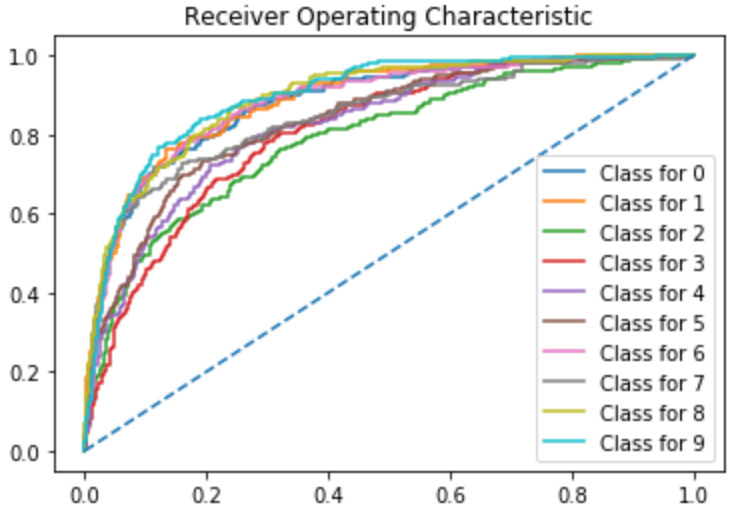


8) OnevsRest classifier for batch 1 fold 2 linear model
Model accuracy is: 0.2855
Confusion Matrix: [[73 12 21 15 7 5 6 10 28 17]
[10 84 4 10 9 6 9 8 11 24]
[17 10 53 24 21 13 40 15 14 10]
[8 11 28 38 14 9 30 16 11 24]
[6 9 27 20 25 9 32 45 15 20]
[13 21 18 43 12 23 30 25 13 12]
[3 12 13 25 23 10 81 15 6 19]
[9 8 21 17 20 12 9 70 6 14]
[44 16 10 14 10 4 7 8 69 22]
[25 43 20 10 15 4 11 12 15 55]]

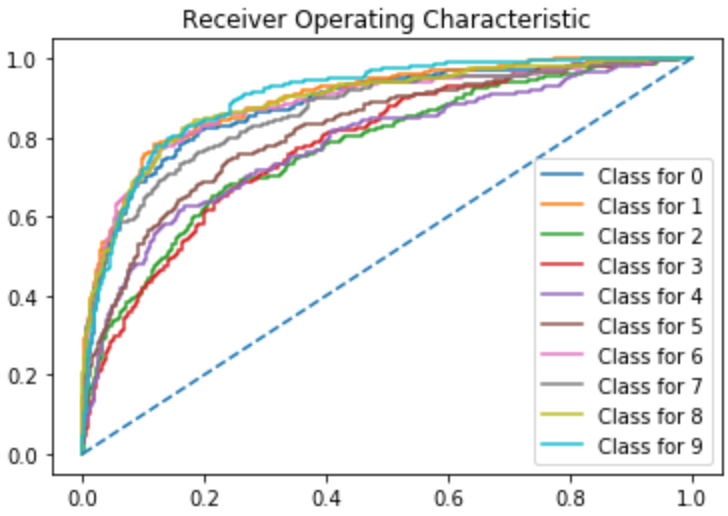


9) OnevsOne classifier for batch 1 fold 2 rbf model
Model accuracy is: 0.478

Confusion Matrix: [[99 7 10 12 6 3 5 6 38 8]
[1 88 5 6 5 5 4 6 14 41]
[20 3 87 25 16 8 29 15 8 6]
[0 6 18 81 15 24 25 9 5 6]
[12 3 39 12 72 6 30 22 5 7]
[3 7 16 57 14 74 15 12 7 5]
[4 0 16 25 19 6 127 4 3 3]
[8 5 12 17 17 7 6 96 8 10]
[22 15 5 9 6 9 3 4 117 14]
[7 41 1 13 2 7 5 4 15 115]]



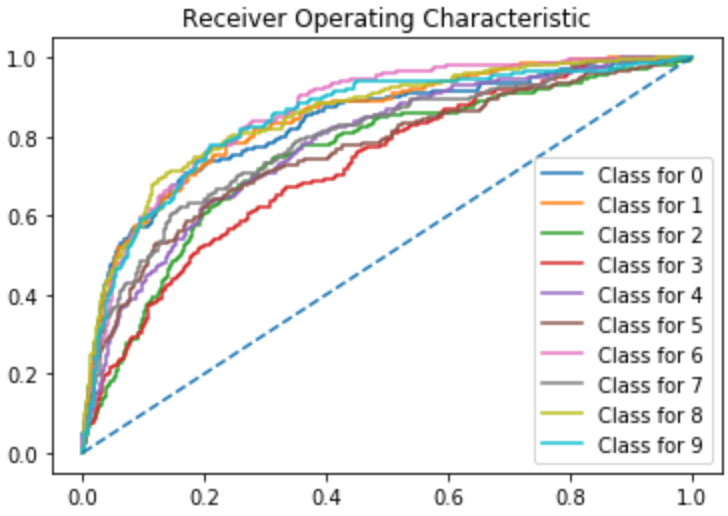
10) OnevsRest classifier for batch 1 fold 2 rbf model
Model accuracy is: 0.4915
Confusion Matrix: [[104 7 8 4 3 4 5 8 42 9]
[1 102 2 2 4 2 6 4 14 38]
[20 9 73 15 18 13 32 19 12 6]
[3 10 15 56 11 30 35 13 10 6]
[9 6 24 12 80 7 28 28 8 6]
[3 10 14 34 15 71 27 19 10 7]
[3 4 8 12 18 6 143 4 4 5]
[5 6 10 8 13 6 7 110 10 11]
[21 16 3 4 4 7 3 5 128 13]
[7 43 0 4 4 7 4 8 17 116]]



11) OnevsOne classifier for batch 1 fold 2 poly model

Model accuracy is: 0.407

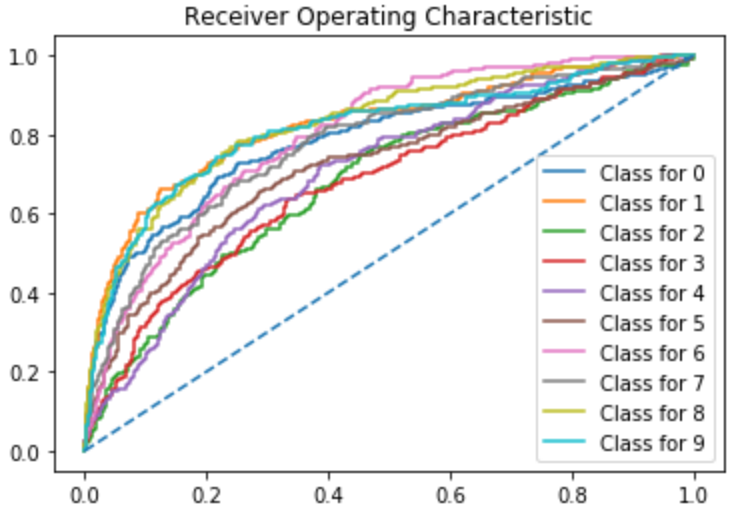
Confusion Matrix: [[96 2 25 9 10 4 8 5 25 10]
[6 71 12 6 7 7 17 7 13 29]
[18 4 87 10 29 6 36 17 9 1]
[6 8 30 46 25 12 49 4 2 7]
[11 4 46 8 83 4 28 17 4 3]
[5 3 35 36 18 51 32 6 12 12]
[3 3 27 9 26 5 128 2 2 2]
[11 4 24 11 35 4 17 65 7 8]
[29 20 14 6 11 6 4 2 100 12]
[11 30 8 8 7 4 16 10 29 87]]



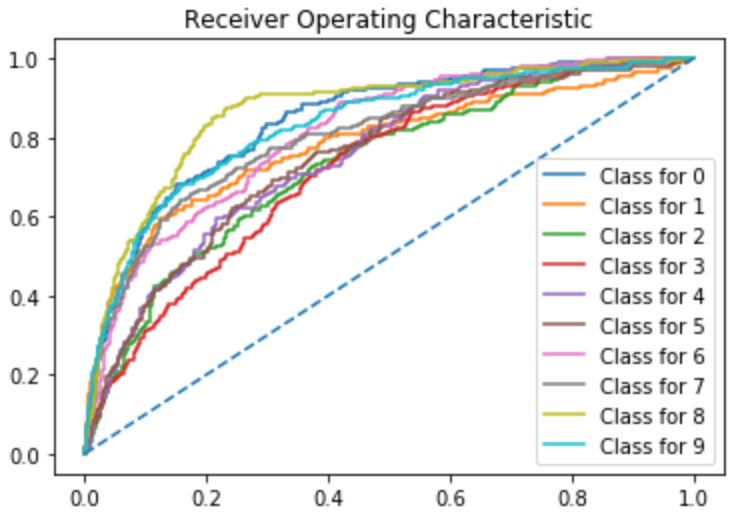
12) OnevsRest classifier for batch 1 fold 2 poly model

Model accuracy is: 0.399

Confusion Matrix: [[92 3 20 7 5 6 8 6 34 13]
[6 90 3 7 1 4 10 10 14 30]
[15 6 60 17 31 15 35 18 17 3]
[8 9 17 48 17 20 41 14 8 7]
[10 6 24 14 72 11 27 30 11 3]
[6 7 19 44 17 54 24 17 14 8]
[3 6 16 25 19 7 114 11 2 4]
[8 10 15 15 24 11 11 72 9 11]
[29 21 5 10 8 4 7 6 105 9]
[7 33 4 13 4 9 11 16 22 91]]



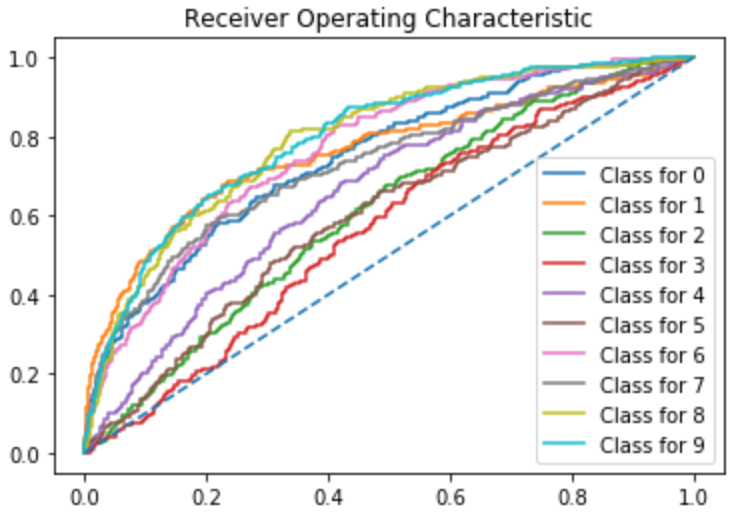
13) OnevsOne classifier for batch 1 fold 3 linear model
Model accuracy is: 0.373
Confusion Matrix: [[91 15 16 11 2 1 4 9 44 21]
[11 84 6 11 4 10 8 13 14 24]
[22 11 45 21 29 16 25 15 12 3]
[4 10 23 53 18 27 22 12 13 14]
[6 4 34 14 51 16 26 26 8 4]
[9 7 15 43 16 50 20 10 12 8]
[1 10 18 38 22 13 82 9 2 7]
[9 8 21 12 27 16 8 86 6 19]
[38 14 2 5 6 9 0 1 113 25]
[14 36 5 7 5 2 8 15 17 91]]



14) OnevsRest classifier for batch 1 fold 3 linear model

Model accuracy is: 0.373

Confusion Matrix: [[91 15 16 11 2 1 4 9 44 21]
[11 84 6 11 4 10 8 13 14 24]
[22 11 45 21 29 16 25 15 12 3]
[4 10 23 53 18 27 22 12 13 14]
[6 4 34 14 51 16 26 26 8 4]
[9 7 15 43 16 50 20 10 12 8]
[1 10 18 38 22 13 82 9 2 7]
[9 8 21 12 27 16 8 86 6 19]
[38 14 2 5 6 9 0 1 113 25]
[14 36 5 7 5 2 8 15 17 91]]

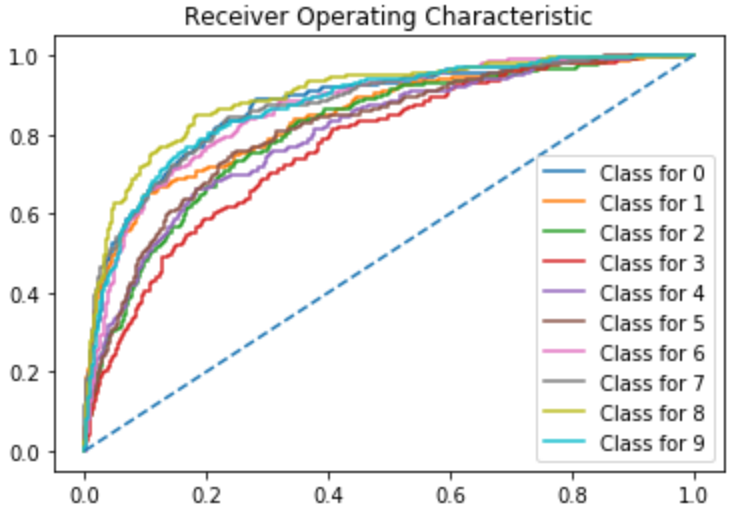


15) OnevsOne classifier for batch 1 fold 3 rbf model

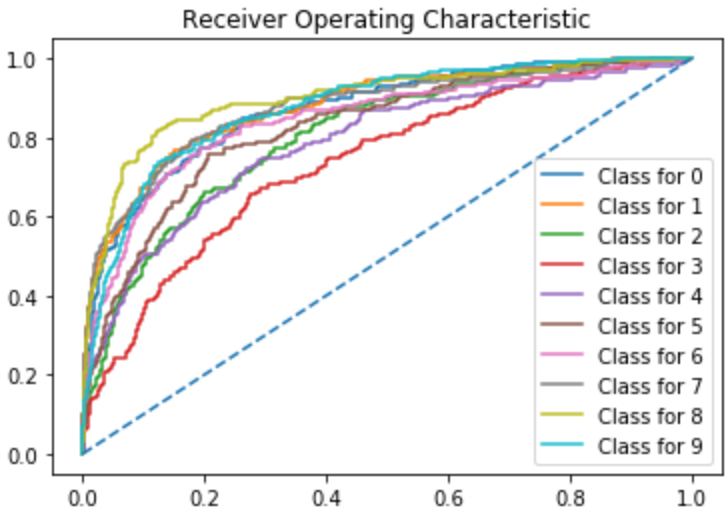
Model accuracy is: 0.461

Confusion Matrix: [[103 10 11 12 7 3 1 6 44 17]

[7 88 7 10 11 9 7 4 12 30]
[17 7 68 21 22 15 28 6 11 4]
[2 3 21 70 23 30 22 4 6 15]
[11 2 21 17 70 8 26 18 7 9]
[2 3 14 57 11 67 13 10 3 10]
[1 5 22 15 25 19 103 6 2 4]
[5 4 16 16 18 18 9 103 5 18]
[17 15 5 7 4 7 4 2 135 17]
[6 30 4 11 4 4 4 9 13 115]]



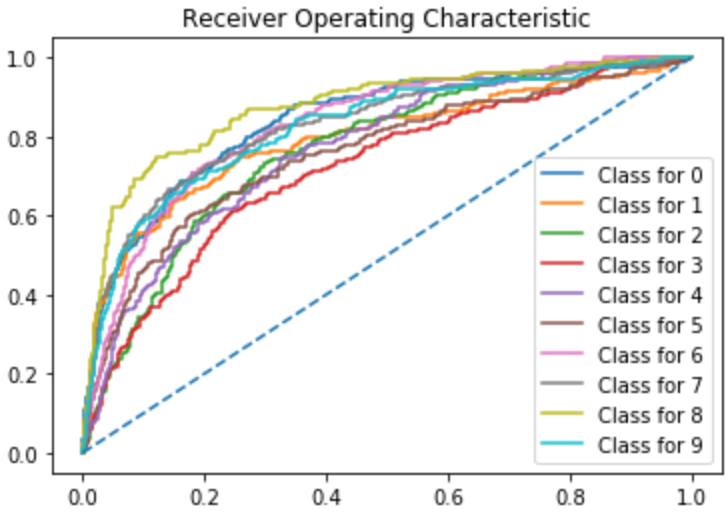
16) OnevsRest classifier for batch 1 fold 3 rbf model
Model accuracy is: 0.4625
Confusion Matrix: [[105 12 12 5 6 3 3 9 42 17]
[9 96 5 6 13 2 7 5 15 27]
[11 8 63 17 24 21 31 10 10 4]
[5 9 19 46 17 31 29 16 7 17]
[10 5 19 12 68 7 32 25 6 5]
[5 4 11 34 9 71 18 20 6 12]
[1 12 14 8 21 15 113 10 6 2]
[6 5 11 8 13 18 10 112 5 24]
[19 19 3 2 3 6 4 1 145 11]
[8 35 4 6 2 5 7 12 15 106]]



17) OnevsOne classifier for batch 1 fold 3 poly model

Model accuracy is: 0.405

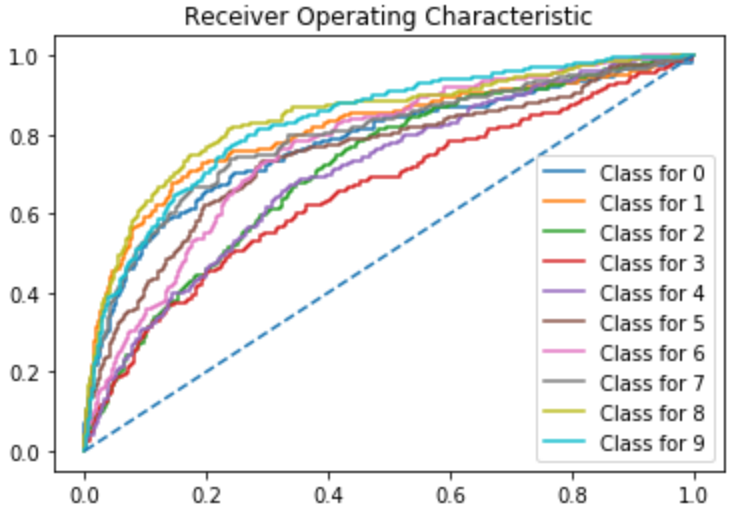
Confusion Matrix: [[91 8 29 6 13 3 7 5 37 15]
[11 72 18 13 12 1 16 3 15 24]
[18 3 76 10 31 9 31 9 10 2]
[5 6 31 45 22 24 43 7 6 7]
[4 1 40 9 72 8 26 19 6 4]
[6 2 30 32 26 52 21 9 6 6]
[1 4 29 14 27 16 103 3 3 2]
[7 4 27 6 35 10 16 86 7 14]
[21 11 14 4 6 6 5 1 134 11]
[14 26 16 10 10 1 16 10 18 79]]



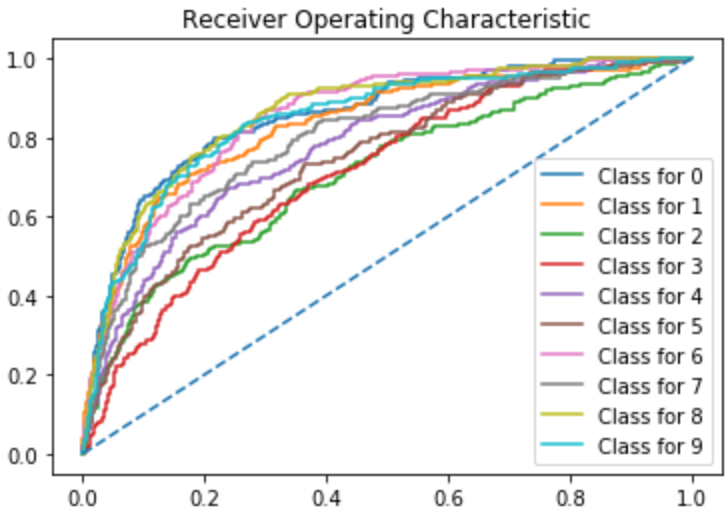
18) OnevsRest classifier for batch 1 fold 3 poly model

Model accuracy is: 0.406

Confusion Matrix: [[88 11 12 14 14 4 6 8 40 17]
[7 92 10 9 15 1 8 7 19 17]
[20 8 54 16 29 17 31 9 9 6]
[6 12 19 37 23 32 39 12 7 9]
[10 5 29 15 69 11 20 18 7 5]
[6 6 9 35 19 63 21 16 10 5]
[2 7 17 18 24 19 96 9 8 2]
[8 9 20 11 25 9 13 96 10 11]
[20 14 1 4 7 9 3 4 133 18]
[11 28 13 10 8 8 14 6 18 84]]



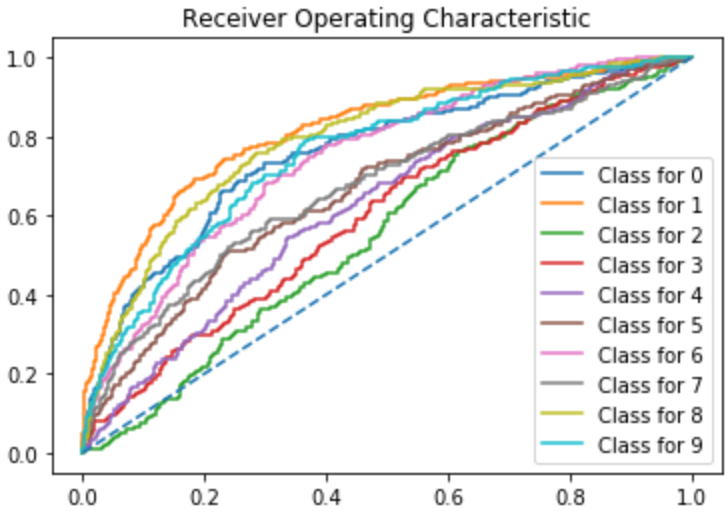
19) OnevsOne classifier for batch 1 fold 4 linear model
Model accuracy is: 0.381
Confusion Matrix: [[89 14 15 9 3 3 2 7 35 9]
[11 93 10 13 3 8 7 15 19 35]
[19 19 61 10 26 10 19 23 8 3]
[7 20 18 52 11 37 35 19 12 18]
[6 4 34 13 62 12 29 20 8 7]
[8 8 24 35 16 44 15 22 5 5]
[3 4 25 34 17 13 103 7 5 5]
[12 10 14 11 34 16 14 84 4 13]
[29 15 2 6 0 8 6 5 94 24]
[14 27 5 4 3 4 13 10 19 80]]



20) OnevsRest classifier for batch 1 fold 4 linear model

Model accuracy is: 0.2825

Confusion Matrix: [[60 16 18 8 5 10 3 3 51 12]
[10 108 13 15 13 7 9 7 15 17]
[13 23 17 30 35 13 31 16 15 5]
[18 17 19 46 12 25 35 16 16 25]
[13 4 18 29 39 22 31 21 7 11]
[19 12 14 26 13 37 29 8 11 13]
[9 7 17 28 26 15 88 13 5 8]
[19 9 11 27 24 17 26 54 6 19]
[29 27 8 7 9 10 9 4 74 12]
[12 49 9 6 9 5 15 10 22 42]]

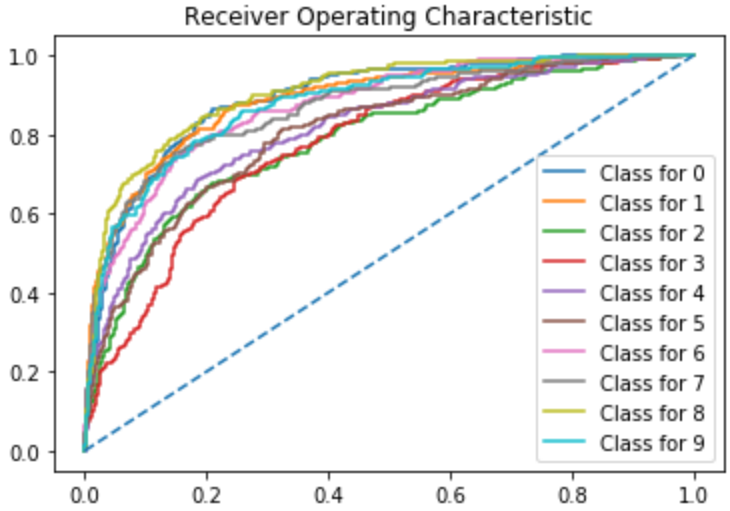


21) OnevsOne classifier for batch 1 fold 4 rbf model

Model accuracy is: 0.468

Confusion Matrix: [[95 4 12 8 5 5 4 1 38 14]

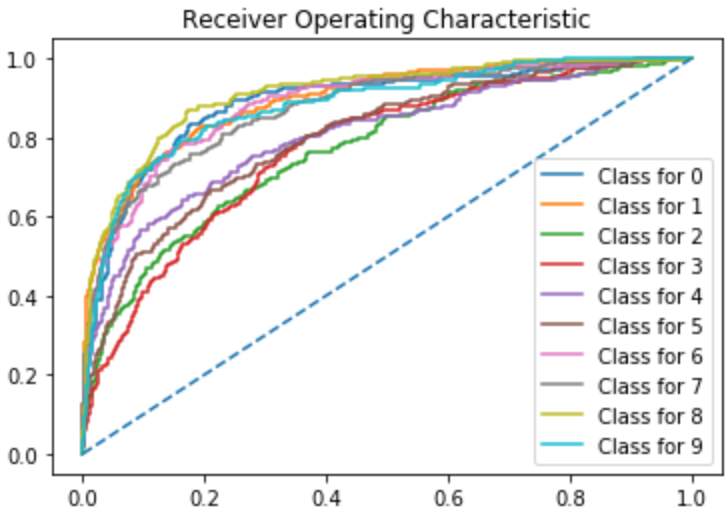
[10 103 8 12 3 6 3 9 14 46]
[21 4 71 19 27 14 16 16 4 6]
[7 7 17 70 7 55 29 13 6 18]
[7 3 30 14 81 10 24 13 6 7]
[6 3 16 38 14 70 13 9 4 9]
[7 6 23 28 19 12 110 2 3 6]
[8 5 6 15 28 11 11 108 2 18]
[18 12 4 10 3 5 2 1 119 15]
[8 20 3 5 3 3 5 5 18 109]]



22) OnevsRest classifier for batch 1 fold 4 rbf model

Model accuracy is: 0.4875

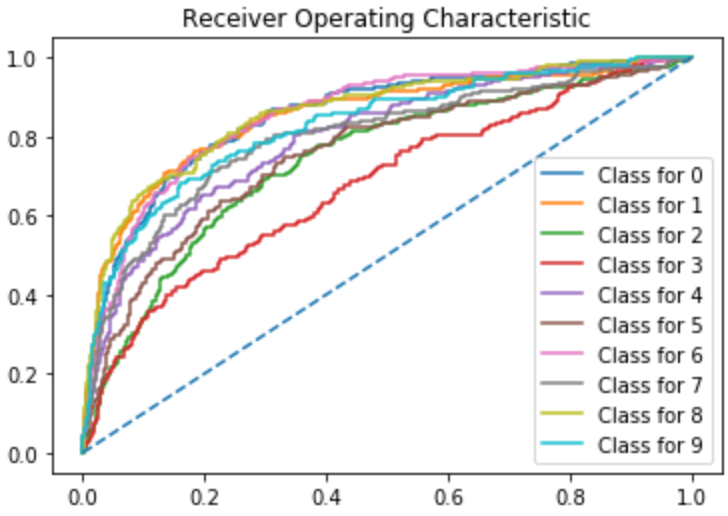
Confusion Matrix: [[100 8 9 2 2 2 8 3 41 11]
[8 129 3 4 3 6 3 10 18 30]
[24 11 62 12 22 11 21 21 8 6]
[8 14 15 57 5 55 30 16 7 22]
[6 6 25 10 83 10 22 21 4 8]
[8 7 17 22 12 70 17 16 4 9]
[6 8 16 10 11 11 133 6 5 10]
[10 8 7 6 16 14 12 116 6 17]
[21 14 3 6 4 3 2 4 122 10]
[8 31 0 3 3 5 6 4 16 103]]



23) OnevsOne classifier for batch 1 fold 4 poly model

Model accuracy is: 0.418

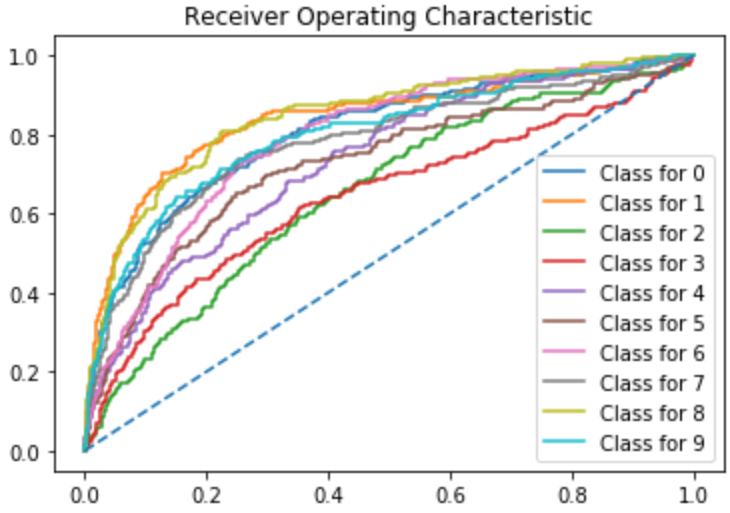
Confusion Matrix: [[88 6 22 6 8 3 5 4 33 11]
[13 98 15 9 7 2 15 10 22 23]
[17 6 79 8 38 5 22 13 7 3]
[8 13 30 49 21 31 40 16 9 12]
[8 1 46 6 92 6 19 11 2 4]
[5 2 35 18 25 44 31 10 7 5]
[2 6 36 12 16 4 133 3 2 2]
[7 3 27 11 43 16 20 71 4 10]
[34 10 11 2 6 4 7 1 104 10]
[15 19 13 3 8 3 17 5 18 78]]



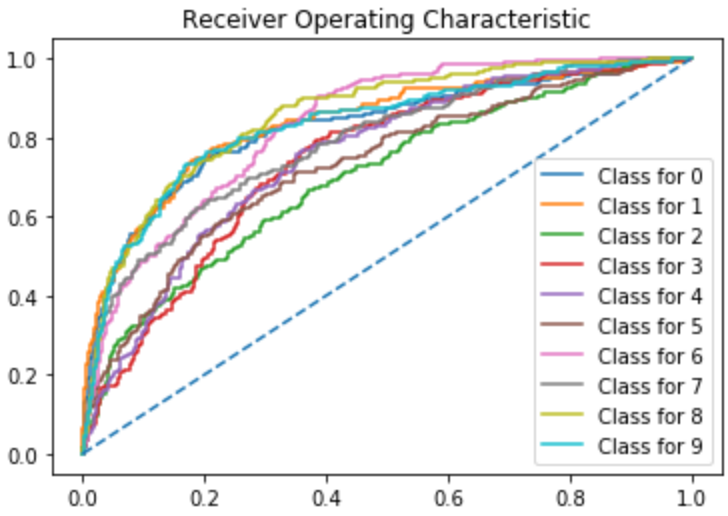
24) OnevsRest classifier for batch 1 fold 4 poly model

Model accuracy is: 0.418

Confusion Matrix: [[89 11 11 4 4 3 10 3 40 11]
[13 108 8 11 9 6 8 13 26 12]
[22 10 51 13 33 17 26 10 10 6]
[14 14 17 54 28 35 36 13 10 8]
[8 6 30 13 80 6 25 10 8 9]
[8 5 22 18 16 57 27 12 8 9]
[10 5 19 15 15 11 119 7 7 8]
[14 7 7 8 23 14 21 94 7 17]
[28 14 5 8 9 3 3 4 105 10]
[16 23 5 6 9 6 10 7 18 79]]



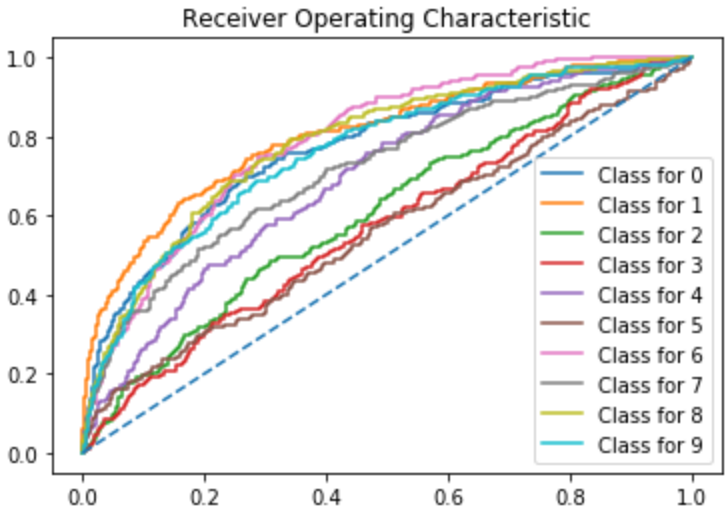
25) OnevsOne classifier for batch 1 fold 5 linear model
Model accuracy is: 0.3865
Confusion Matrix: [[96 12 11 12 6 7 2 12 36 15]
[7 101 11 6 4 14 7 9 16 34]
[20 12 65 17 25 14 28 17 12 5]
[12 16 20 47 13 41 30 9 7 12]
[13 7 31 12 40 19 33 27 6 5]
[4 9 17 37 11 49 19 15 5 6]
[1 9 18 27 22 17 90 6 4 4]
[10 6 18 13 19 20 11 80 5 10]
[28 12 13 6 3 9 5 7 109 24]
[14 27 6 5 2 6 12 8 13 96]]



26) OnevsRest classifier for batch 1 fold 5 linear model

Model accuracy is: 0.304

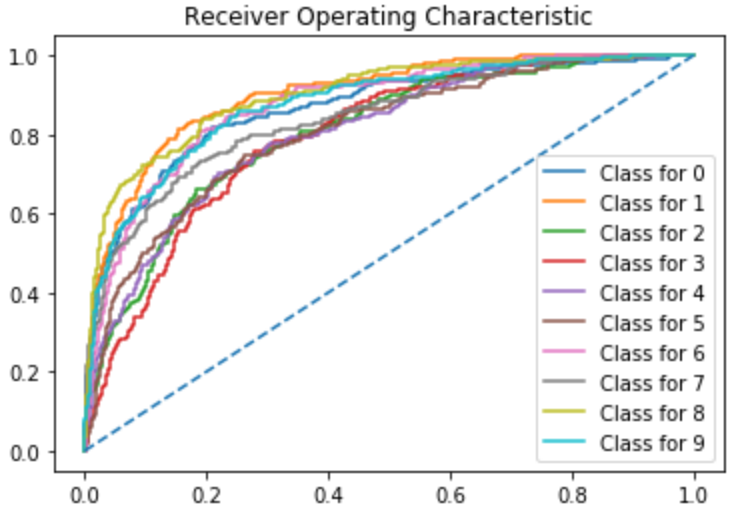
Confusion Matrix: [[75 17 5 8 8 7 5 23 43 18]
[19 99 7 10 13 7 11 13 13 17]
[20 12 46 18 34 14 21 23 20 7]
[21 9 14 32 28 29 35 15 14 10]
[10 5 35 12 53 8 32 20 9 9]
[13 15 18 23 30 22 24 10 11 6]
[2 9 16 29 22 11 79 10 9 11]
[23 5 20 16 33 5 6 60 10 14]
[34 20 10 13 6 6 5 7 91 24]
[20 39 7 17 5 7 14 12 17 51]]



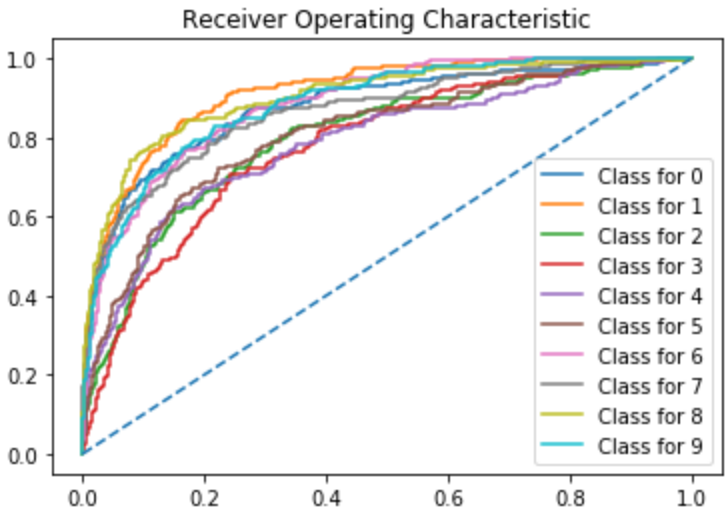
27) OnevsOne classifier for batch 1 fold 5 rbf model

Model accuracy is: 0.4675

Confusion Matrix: [[113 14 15 8 6 1 3 8 35 6]
[6 109 4 11 2 3 5 8 14 47]
[24 2 80 24 30 9 22 12 6 6]
[10 5 21 61 11 50 24 12 4 9]
[18 3 36 13 64 14 23 14 3 5]
[5 2 12 36 7 76 14 14 2 4]
[5 4 22 16 24 18 95 6 3 5]
[11 5 14 13 15 15 10 95 3 11]
[18 16 6 4 5 7 3 4 135 18]
[10 25 2 10 3 4 7 7 14 107]]



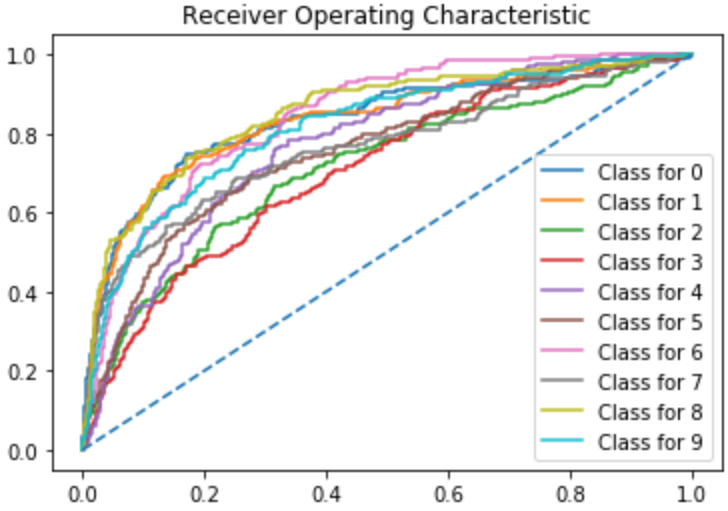
28) OnevsRest classifier for batch 1 fold 5 rbf model
Model accuracy is: 0.4815
Confusion Matrix: [[116 15 13 2 2 5 5 5 38 8]
[8 119 1 4 5 4 6 9 16 37]
[20 10 74 13 33 17 25 10 8 5]
[14 13 13 49 12 40 31 21 3 11]
[17 10 30 8 56 8 26 23 9 6]
[5 6 12 23 12 72 18 15 5 4]
[5 6 17 13 14 9 118 9 3 4]
[10 5 10 7 15 11 11 110 4 9]
[16 22 3 3 3 3 0 6 142 18]
[9 31 2 3 4 6 10 6 11 107]]



29) OnevsOne classifier for batch 1 fold 5 poly model

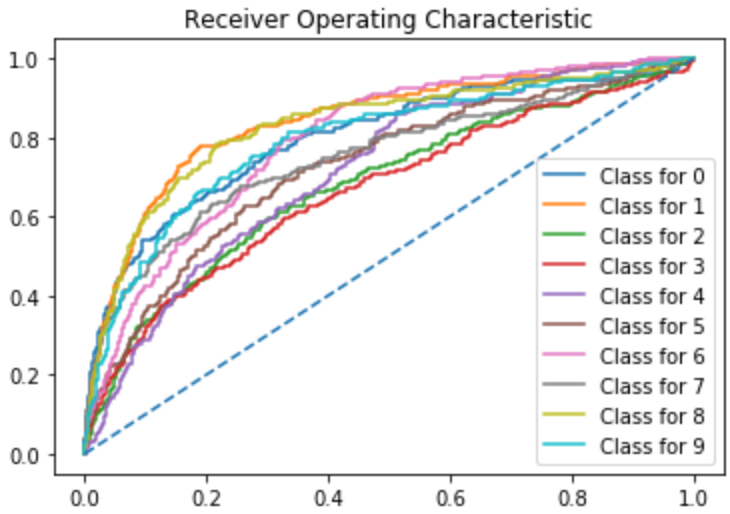
Model accuracy is: 0.402

Confusion Matrix: [[104 3 23 4 12 3 15 6 37 2]
[9 91 17 4 8 5 18 3 19 35]
[26 3 86 6 37 6 26 11 7 7]
[8 5 29 40 23 40 35 8 7 12]
[13 2 49 9 65 8 28 12 5 2]
[1 2 24 29 20 39 34 14 2 7]
[3 3 35 10 24 7 106 3 3 4]
[8 4 24 12 26 11 20 76 8 3]
[27 14 19 4 5 3 7 6 120 11]
[12 32 12 10 7 1 16 6 16 77]]



30) OnevsRest classifier for batch 1 fold 5 poly model

Model accuracy is: 0.408
Confusion Matrix: [[95 13 11   5 10   6 10   9 44   6]
 [13 104   3   5   8   7 11   6 18 34]
 [21   7 63 15 45 10 18 12 17   7]
 [12 10 16 48 23 46 22 13   6 11]
 [16   6 26 15 63 11 18 21 10   7]
 [3   9 21 28 14 41 26 15   8   7]
 [3   8 16 17 17 13 105   9   3   7]
 [10   9 13 10 19 14 14 84 11   8]
 [25 14 10   5   5   6   9   7 123 12]
 [9 28   4   9   4   8 11 11 15 90]]



As seen from the plots and results, rbf kernel performs the best.